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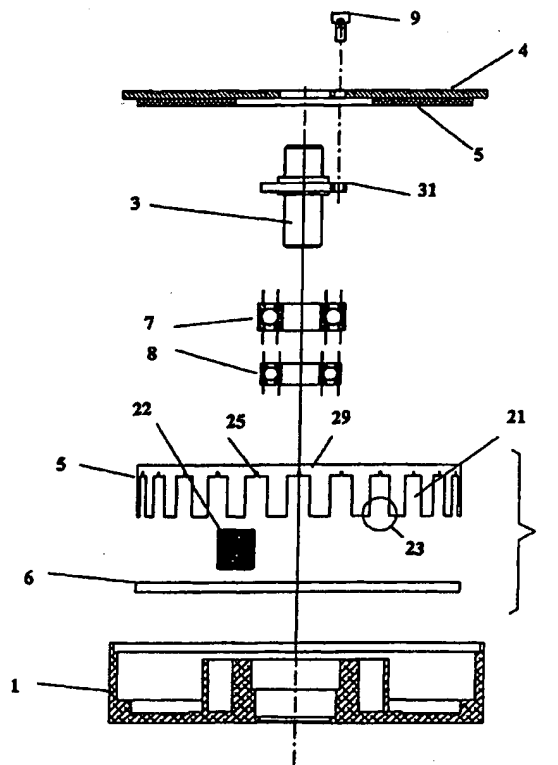
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(54) Title: AXIAL AIR GAP BRUSHLESS MOTOR AND METHOD FOR MANUFACTURING SUCH MOTOR

(57) Abstract

Axial air gap brushless motor, comprising a casing (1), a stator (2) equipped with stator coils (22), a rotatably supported shaft (3) and a disc-shaped rotor (4) mounted on said shaft, with a magnetic disc (5) secured to said motor. The stator comprises a stator body (5) equipped with slots (21) for receiving the stator coils (22), that are substantially closed on the side facing the rotor (4, 5) and provide - on the opposite side facing the stator when the motor is assembled - openings (23) wide enough to allow the passage of already wound coils. Such openings are closed by a stator annular plate (6) mounted on said stator body on the side facing the bottom of said casing (1).



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5 "AXIAL AIR GAP BRUSHLESS MOTOR AND METHOD FOR MANUFACTURING SUCH MOTOR".

Technical Field

10 This invention relates to brushless motors, and in particular to axial air gap servomotors, as well as to a method for manufacturing such electric motors. The invention advantageously applies to the so called "flat-type" brushless motors.

15 Background Art

As it is known, an axial (air gap) brushless motor comprises a motor shaft to which an assembly comprising a disc-shaped rotor and an annular permanent magnet is fastened, and a stator provided with a plurality of winding coils lodged in stator slots. By properly feeding the coils, the magnetic field generated interacts with the permanent magnet field and causes the rotation of the rotor assembly. By eliminating the brushes and the switching components several advantages can be achieved in respect of the conventional motors, such as for example an improved machine efficiency and a reduction of the electrically generated noise and disturbances. Besides, the motor is substantially maintenance-free and its performances are maintained constant for a long time.

20 Examples of flat-type brushless motors are described in US-A-4 361 776 and US-A-4 851 731.

35 However, the known axial air gap brushless motors have several limitations and drawbacks.

40 In particular, the assembling of the coils to the stator, either by inserting previously formed coils into the slots or by winding the coils in the slots, is rather difficult and brings about large manufacturing costs of the motor.

45 Additionally, the known arrangements of motors with open slots are often an obstacle to obtain a high torque.

50 Finally, for assembling the parts together the use of screws or other locking elements is required which further increases the motor cost and make difficult the automatic assembling thereof.

### Disclosure of the Invention

5 An object of the present invention is to provide a brushless motor of the above mentioned type that overcomes the above illustrated drawbacks of the prior art, and more particularly to provide a lower-cost brushless motor with improved performance that nevertheless can be manufactured and assembled quite easily.

10

Another object of the invention is to provide a brushless motor that can be assembled without requiring the use of screws or other mechanical fastening elements.

15

These objects are achieved through a brushless motor according to claim 1 and an assembling method according to claim 7, and a stator body as claimed in claim 6. Further advantageous features are recited in the depending claims.

20

A brushless motor according to the invention comprises a magnetic circuit provided on the stator side with a plurality of slots with a conventional opening, while on the opposite side it allows for the insertion of a winding consisting of a plurality of complete coils formed in advance, in case wound onto a support.

25

With this arrangement it is possible to obtain a motor supplying a torque larger than that of conventional motors and having a quiet running even at the maximum torque (inductively 3 times the nominal torque).

30

Besides, by inserting the complete coils, it is possible to reduce the time for their assembling, which in turn reduces the overall assembling cost. When assembling the motor of the invention, advantage is further taken from the attraction between the magnets located on the rotor, whereby the servomotor can be assembled by merely approaching the parts to one another. The magnetic retaining forces are such that the motor can only be disassembled by using a suitable extractor tool, in spite of the fact that no screws or fastening means are used to join together the stator, the rotor and the casing.

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### Brief Description of Drawings

The invention will now be disclosed hereinbelow with reference to the accompanying drawings illustrating preferred but non limiting embodiments thereof, in which:

45

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Fig. 1 is an exploded view which illustrates schematically the structure of a brushless motor according to the invention;

5 Fig. 2 shows the stator with bobbins or coils impregnated with synthetic resin before the stator slots are machined; and

10 Fig. 3 shows a stator after a portion thereof has been removed and ready to be assembled to the rest of the motor.

With reference to Fig. 1, a servomotor according to the invention comprises a casing 1 housing a stator 2 and a motor shaft 3 rotatably supported through bearings 7 and 8.

15 At one end of the motor shaft 3 there is mounted an assembly formed by a disc-shaped rotor 4 and a disc 5 of a magnetic material (permanent magnet) which is coaxial with and secured to the rotor. The rotor-magnetic disc assembly  
20 is secured to the shaft 3 by three screws 9 (only one shown in Fig. 1) that engage corresponding holes in a flange 31 of the shaft 3.

The stator 2 comprises a stator body 5, provided with  
25 slots 21 for housing the coils or bobbins 22 (only one is shown in the Figure), and an annular plate or stator crown 6.

According to the invention, in the assembled motor, as  
30 will be better disclosed with reference to Figs. 2 and 3, the slots 21 for receiving the coils are substantially closed towards the rotor. However, before the assembling, the stator body 5 is provided with a closing wall 29 on the side of the stator body 5 facing the rotor, while on the  
35 opposite side the slots 21 are opened with openings 23 that allow the passage of the coils 22. Such openings 23 are then closed by the stator crown 6, separately manufactured and applied after the winding has been inserted, as better shown in Fig. 2.

40 The term "substantially closed" means that in the assembled motor, on the side facing the rotor, each slot 21 terminates with a small opening, preferably in form of a narrow slit (24 in Fig. 3) with a width in the order of 1  
45 mm., but anyhow insufficient to allow the passage of the coil located in the slot 21.

As illustrated in Fig. 1 showing the motor parts before they are assembled together, the openings 23  
50 provided for in the stator slots 21 on the side opposite to that facing the rotor assembly 4-5, are dimensioned so as

to allow the introduction of the coils 22 already completely wound. On the opposite side, still in the stator to be assembled, the slots 21 are completely closed on the side facing the rotor, and preferably provided with a notch  
5 25 on the bottom of slot.

The method of the invention for manufacturing and assembling a flat brushless motor provides for introducing the already wound coils 22 into the slots 21 through the openings 23 on the stator side facing the bottom of the casing 1, and their impregnation with resin as shown in  
10 Fig. 2. Alternatively the coils can be wound by introducing the wires from the openings 23.

Later on, after the resin has been set, the stator is  
15 mechanically machined on the side facing the rotor, until the notches 25 are reached. Consequently the notches become open slits 24 thus obtaining the assembly illustrated in Fig. 3 which will be then joined to the remaining parts forming the motor.

20 The open slits 24 created in the closing wall 29 of the slots 21 have the function to optimise the magnetic circuit and to make noiseless the motor.

25 Thanks to the proposed arrangement the motor parts are kept in their positions only by the magnetic force and no screws or other mechanical fastening elements are required for assembling the main components of the brushless motor according to the invention.

30 The removal of stator material up to exposing the notches 25 can be accomplished chemically, e.g. by properly etching the stator surface, or otherwise. As an alternative, the stator could be provided with open slits  
35 24 closed by an annular plate (not shown in the drawings) that is temporarily secured to the stator and is removed after the coils have been mounted and impregnated.

40 Although the invention has been illustrated with reference to preferred embodiments thereof, it is generally subjected to other applications and modifications falling within the scope of the invention, as it will be evident to the skilled of the art.

#### 45 Industrial Applicability

The invention applies to the manufacturing and assembling of flat brushless electric motors.

C L A I M S

5

1. An axial air gap brushless motor, comprising a casing (1), a stator (2) equipped with stator coils (22), a rotatably supported shaft (3) and a disc-shaped rotor (4) mounted on said shaft, with a disc made-up of magnetic material (5) secured to said rotor, characterised in that  
10 said stator comprises:

a stator body (5) provided with slots (21) for housing the stator coils (22) that are substantially closed on the  
15 side facing the rotor (4, 5), and provide - on the opposite side facing the stator in the assembled motor, openings (23) wide enough to allow the passage of the already wound coils, and

20 a stator annular plate (6) mounted on said stator body on the side facing the bottom of said casing (1).

2. A brushless motor as claimed in claim 1, characterised in that said slots (21) terminates, on the  
25 side facing the rotor (4), with openings too narrow to allow the passage of said wound coils (22).

3. A brushless motor as claimed in claims 1 or 2, characterised in that said slots (21) of the stator body  
30 (5) are completely closed (29) on the side facing the rotor (4).

4. A brushless motor as claimed in the preceding claims, characterised in that their components are held  
35 together by the magnetic force during the assembling and require no mechanical fastening elements.

5. A brushless motor as claimed in the preceding claims, characterised in that said motor is of flat-type.  
40

6. A stator body (5) for a brushless motor as claimed in claims 1 to 5, characterised by providing a wall (29) closing said slots (21) on the side that will be facing  
45 said rotor (4), with notches (25) on the bottom of said slots.

50



7. A method for manufacturing and assembling an axial air gap brushless motor comprising the steps of:

- 5 a) providing a stator body (5) equipped with slots (21) for receiving the stator coils that are substantially closed on one side (29) and opened (23) on the opposite side;
- 10 b) inserting into said slots (21) from the open side (23) thereof, a winding assembly made-up by a plurality of previously wound coils (22);
- 15 c) closing the openings (23) of said slots (21) by means of a stator annular plate (6);
- d) inserting the so formed assembly into the casing (1) of the motor with said stator plate (6) facing the bottom of said casing;
- 20 e) mounting to said stator (2) a rotor shaft (3) carrying an assembly made-up of a disc-shaped rotor (4) and a magnetic disc (5) secured to said rotor, said rotor assembly (4, 5) being located on the side of said substantially closed slots.

25

8. A method as claimed in claim 7, characterised in that it provides a further step c1) of impregnating with resin said stator (2) housing the assembled coils (22).

30

9. A method as claimed in claim 7, characterised in that it provides a further step c2) of removing stator material from the side facing said rotor assembly such removal being however insufficient to allow the passage of said wound coils (21).

35

10. A method as claimed in claim 9 when applied to a stator body as claimed in claim 6, characterised in that said stator material is removed by mechanical machining until reaching said notches (25).

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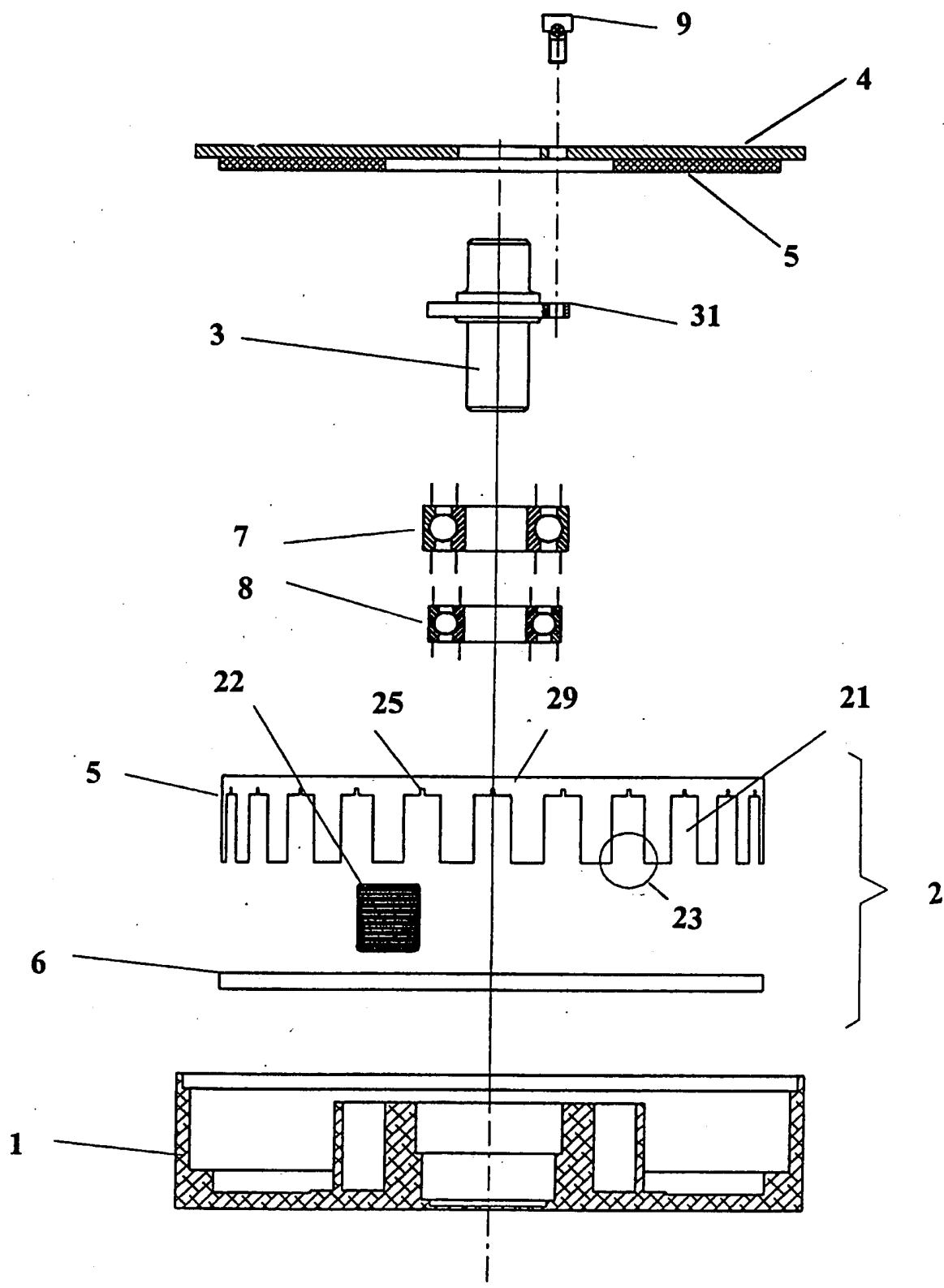


Fig. 1

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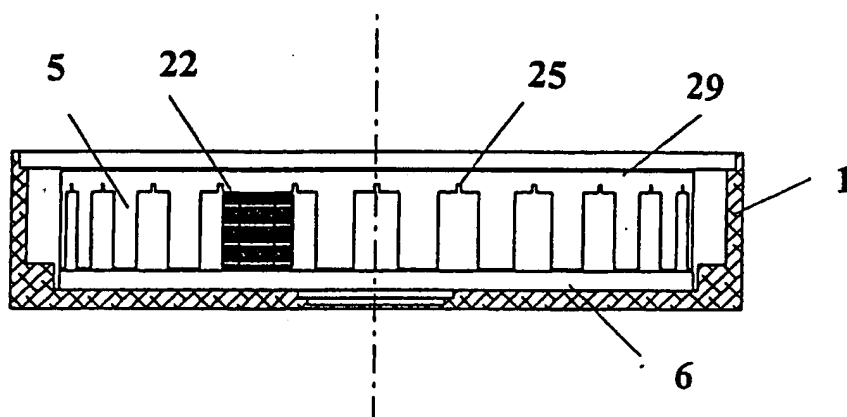


Fig. 2

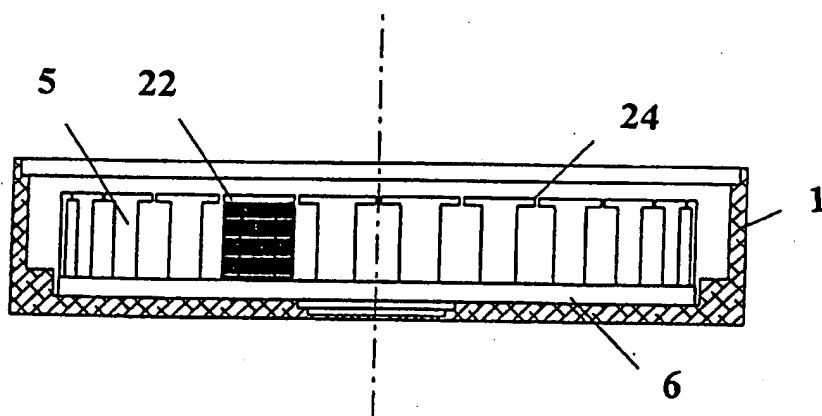


Fig. 3